



Arthur Allen

## Northern Goshawk

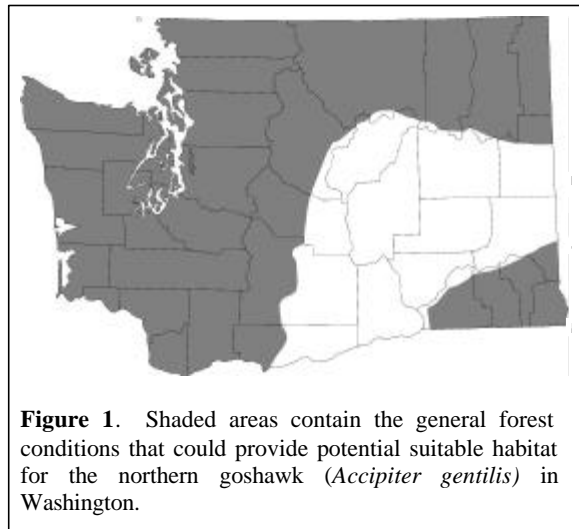
*Accipiter gentilis*

Written by Steven M. Desimone and David W. Hays

### GENERAL RANGE AND WASHINGTON DISTRIBUTION

The northern goshawk (*Accipiter gentilis*) is holarctic in distribution, occupying a wide variety of boreal and montane forest habitats throughout Eurasia and North America (Palmer 1988, Johnsgard 1990). Three subspecies of the goshawk are recognized in North America (Johnsgard 1990, James and Palmer 1997), but only the northern goshawk (*A.g. atricapillus*) is known in Washington.

Northern goshawks can occur in all forested regions of Washington (see Figure 1). As of 2003, there were 338 documented breeding territories in the state (Washington Department of Fish and Wildlife [WDFW], unpublished data). The exact number is not known, because monitoring is not currently being conducted. The number of historical breeding sites lost due to habitat alteration and the number of new territories in suitable habitat are also unknown. About 50% of the documented breeding territories occur in the eastern Cascades, 27% in the western Cascades, 12% in other forested areas of northeast and southeast Washington, and 10% in the Olympic Peninsula (WDFW, unpublished data). Breeding birds formerly occurred in the Puget trough (Jewett et al. 1953). Less than one percent of recent breeding records have been recorded from this area and southwest Washington (south of the Puget Sound and west to the coast). Wintering goshawk populations in Washington include resident birds (Bloxtom 2002; WDFW, unpublished data) and migrants that move into the state during winters when food shortages occur in their territories (Squires and Reynolds 1997). Overall, densities of territorial pairs in Washington appear to be lower than elsewhere in the western United States (Table 1) but this is partly dependent on habitat quality.



**Figure 1.** Shaded areas contain the general forest conditions that could provide potential suitable habitat for the northern goshawk (*Accipiter gentilis*) in Washington.

**Table 1.** Density estimates of northern goshawk territories in the western United States. Forest management in the study areas ranged from intensive to minimal timber harvest.

Study	Number of pairs	Mean distance (km) to nearest-neighbor	Density (territories/1000 ha)	Spacing (ha/pair)	Reference
Western Washington industrial forest	3	-	0.04-0.13	-	Bosakowski et al. 1999
Upper Yakima River, Washington	1	-	0.1 <sup>a, b</sup>	9091	Wagenknecht et al. 1998
	4	-	0.5 <sup>a, c</sup>	2083	
	5	-	0.5 <sup>a, d</sup>	1852	
Eastern Oregon National Forests	20	4.4	0.7	1538	DeStefano et al. 1994
Eastern Oregon	4	5.6	-	2750	Reynolds and Wight 1978
Klamath National Forest, California	21	3.3	0.6 - 1.1	1750 - 935	Woodbridge and Detrich 1994
North Kaibab NF, Arizona	100	2.5	2.0	491	Reynolds 1997, Reynolds and Joy 1998

<sup>a</sup> Estimate calculated with one year of survey data in each forest type; <sup>b</sup> Open Douglas-fir/ponderosa pine;

<sup>c</sup> mixed conifer-lodgepole pine; <sup>d</sup> mixed Douglas-fir, grand fir, western hemlock

## RATIONALE

The northern goshawk is a Federal Species of Concern and State Candidate species in Washington because of concerns about its population status. Although a decline in populations of northern goshawks has been suggested based on reduced nesting in areas of extensive harvest of mature forest (Crocker-Bedford 1990, 1995; Ward et al. 1992), Kennedy (1997) found no evidence to support the contention that goshawk populations in the western United States were declining, increasing, or stable. Kennedy (1997) acknowledged, however, that population declines might not be apparent due to insufficient sampling techniques. In Washington, goshawks appear to have been largely extirpated from urbanized landscapes and from some areas that are moderately developed or intensively managed for timber on short rotations (WDFW, unpublished data). There are no studies evaluating the population status of the goshawk in the Pacific Northwest. Because goshawks build multiple nests within nesting territories that are often used by other raptor species (Moore and Henny 1983, Buchanan et al. 1993; S. Desimone, unpublished data), the loss of goshawks might indirectly affect other forest species.

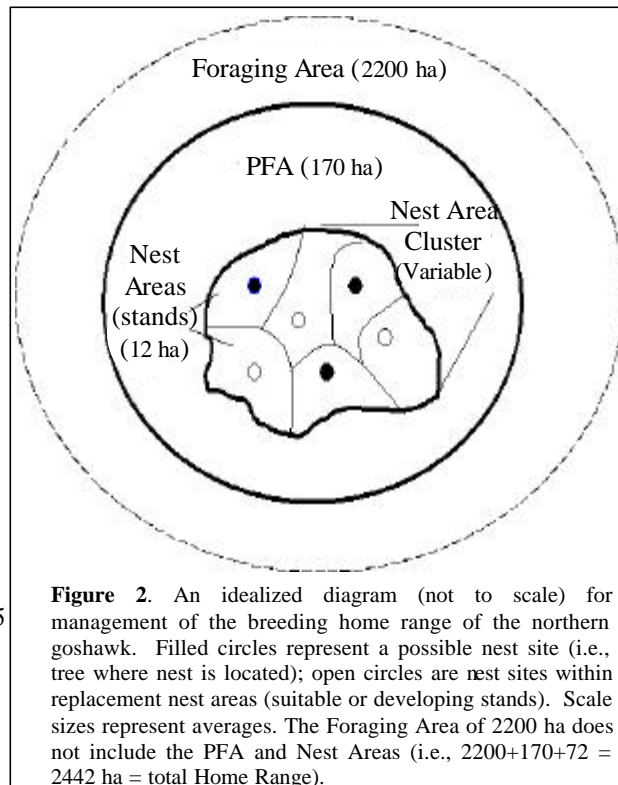
## HABITAT REQUIREMENTS

Research in western North America suggested that the home range of breeding goshawks can be split into three functional divisions: the nest area or areas, the post-fledging family area (PFA), and the foraging area; the sum of these areas compose a northern goshawk's home range (Reynolds et al. 1992) (Figure 2). Habitat information relevant to each of these scales is provided below.

## Nest Area

The nest area (in some studies referred to as the *nest stand*) is composed of one to several forest stands that contain the active and alternate nest structures (Figure 2). Usually occupied by breeding goshawks from March until September, nest area boundaries are determined by the movement and behavior of the adults and newly fledged young, and by the locations of prey plucking areas and roosts that are usually within the nest area. (Reynolds et al. 1982). The term “occupied” is defined by the presence of at least one adult goshawk in the area or territory during a breeding season surveys (Desimone 1997; Finn et al. 2002a, b). The size of nest areas ranged between 8-12 ha (20-30 ac) (Reynolds 1983, Crocker-Bedford and Chaney 1988, Reynolds et al. 1992), but other studies suggest that nest areas can be larger (39 ha [96 ac; Finn et al. 2002a] up to 115 ha [284; Woodbridge and Detrich 1994]).

Within the nest area, the nest site is defined for this document as the immediate vicinity surrounding the nest tree, usually = 1.0 ha (2.5 ac; see McGrath et al. 2003). Goshawks in Washington nest almost exclusively in coniferous forest, although a few nests have been found in smaller aspen (*Populus* spp.) groves within the larger coniferous forest landscape in Okanogan County, Washington (WDFW, unpublished data; S. Desimone, personal observation).



**Stand age.** Studies in North America indicate that goshawks typically select mature or old forest habitat for nesting (Reynolds et al. 1982, Moore and Henny 1983, Fleming 1987, Crocker-Bedford and Chaney 1988, McGrath 1997, Daw and DeStefano 2001; Finn et al. 2002a, b). Research in Washington and Oregon has shown links between nest stand occupancy and forest stand age. Finn et al. (2002a) found late-seral forest consistently averaged 64-75% of the nest areas (39 ha [96 ac]), PFA (177 ha [437 ac]) and home ranges (1886 ha [4660 ac]) of occupied goshawk territories on the Olympic Peninsula, and the average age of trees at occupied nest stands in managed and unmanaged forest were 147 years (95% CI 97-198) (Finn et al. 2002b). These forests are generally characterized by large sawtimber, >50% canopy closure, two or more canopy layers, gaps in the canopy, abundance of large diameter crowns, and the presence of shade tolerant trees. Most goshawk nests in eastern Washington (Finn 1994, McGrath 1997; J. Buchanan, unpublished data) and Oregon (Reynolds et al. 1982, Desimone 1997, Daw and DeStefano 2001, McGrath et al. 2003) were in mature or older forest. In eastern Oregon, Daw and DeStefano (2001) showed that goshawk nest stands were negatively associated with regenerating and young (average diameter at breast height [dbh]: 12-22 cm [5-9 in]) forest at the nest stand scale (10 ha [25 ac]). In east-central Washington and eastern Oregon, McGrath (1997) determined that increasing the amount of early-seral forest by 1% within specified areas surrounding the nest tree would decrease the odds of the site being suitable for nesting by 10%.

Finn (unpublished data) studied landscape patterns and habitat patch features around 25 goshawk nests in the upper Yakima River basin from 1992-1996. They found that the landscape surrounding nests was more

homogeneous and contained less seedling/sapling and forest edge than what was available at the combined nest areas scale (32 ha [79 ac]) and at the post-fledging family area scale (210 ha [519 ac]). At the foraging range scale (3,566 ha [8,812 ac]), no differences were found between areas used by goshawks versus other areas in the landscape.

*Tree density.* Goshawk nest areas generally have a high density of large trees. On the Olympic Peninsula, the average diameter of trees within occupied nest areas was 59 cm (23 in; 95% CI 51 - 67cm) (Finn et al. 2002b). These stands had more large-diameter ( $\geq 63$ cm [25.7 in; 95% CI 22-59 cm]) trees than unoccupied historic nest areas. In the Olympic Peninsula and western Cascades, dominant and co-dominant trees in nesting stands averaged 43-48 cm (17-19 in) dbh and generally exceeded 27 m (89 ft) in height (Fleming 1987). On average, there were 482 trees/ha (195 trees/acre)  $>6$  cm dbh (2.4 in) within nest stands in eastern Oregon (Reynolds et al. 1982). Finn (1994) found that goshawk nest stands contained more snags and down woody material, had greater basal area, and an increased number of tree species than random plots in Okanogan County, Washington.

*Canopy attributes.* Researchers have used various methods to measure forest canopy and this may influence the ability to compare different data sets. Despite this, the overwhelming majority of stands used by nesting goshawks have relatively closed canopies (i.e.,  $>50\%$ ) and are often characterized by multiple canopy layers. In western Washington, Fleming (1987) found goshawk nests in stands with an average canopy closure of about 60-65%. Additionally, nest stands had one to three canopy layers with generally poor development of understory vegetation. Similarly, Finn et al. (2002b) found that canopy closure in occupied nest areas averaged 78% in the Olympic Peninsula. Occupied nest areas had relatively greater canopy depth (i.e., the difference between the average maximum and minimum overstory height; Finn et al. 2002a) as compared to unoccupied historic nest areas. The odds of occupancy at historical nest areas increased with increasing overstory canopy depth (Finn et al. 2002a). Greater canopy depth coupled with low shrub density best discriminated occupied nest areas versus unoccupied historic nest areas (Finn et al. 2002a). This research also showed that occupancy of a stand by goshawks decreased by 47% with each 10% increase in understory shrub cover. Overall, increasing early-seral forest cover was associated with decreasing goshawk occupancy at historical nest stands on the Olympic Peninsula (Finn et al. 2002a).

Canopy attributes east of the Cascades are relatively similar to the previously discussed west-side attributes. Goshawk nest stands in eastern Oregon typically had multi-layered canopies with green foliage occurring a few meters to over 40 m (131 ft) above the ground, and the tops of understory trees overlapped with the lower crowns of overstory trees (Reynolds et al. 1982). In Okanogan County, average overstory canopy closure in nest stands was 75% (Finn 1994), and canopy closure in the eastern Cascades averaged 74% in stands where spotted owls exploited goshawk nests for breeding (J. Buchanan, personal communication). In east-central Washington, canopy closure averaged 73% (McGrath 1997). In eastern Oregon, mean canopy closure was 60% (Reynolds et al. 1982) and 88% (Moore and Henny 1983) within nest stands.

*Size.* The sizes of goshawk nest areas in the Pacific Northwest are variable. On the Olympic Peninsula, occupied goshawk nest areas averaged 33 ha (82 ac) (range: 12-69 ha [30-170 ac]) (Finn et al. 2002b). The conclusions of Finn et al. (2002a) indicated that the composition of nest areas was largely (about 67%) late-seral forest.

In eastern Oregon, Reynolds and Wight (1978) found that the size of nest areas or stands varied with topography and the availability of large trees in dense patches of at least 10 ha (25 ac). Woodbridge and Detrich (1994) found that goshawk territories in northern California contained one to five different forested nesting stands (average = 2). These nest stands were homogeneous in composition, age, and structure relative to the surrounding forest (Woodbridge and Detrich 1994). Stands  $<10$  ha (25 ac) typically contained one or two nests that were occasionally occupied by goshawks, whereas stands  $>20$  ha (49 ac) often contained several nests that were frequently occupied (Woodbridge and Detrich 1994).

*Spacing and number of nests.* Established pairs of goshawks have multiple nest areas that are often structurally similar within a home range (Reynolds et al. 1992). Goshawks may build =10 nest structures within a territory that can be occupied over multiple generations (Crocker-Bedford 1990; S. Joy and T. Fleming, personal communications). In western Washington, the distance between alternate nests of the same territory averaged 536 m (1759 ft) (S. Finn, unpublished data). In more arid forested habitats such as pine and mixed conifer, the average distance between alternate nests within a territory ranged between 245 and 273 m (804-896 ft) (Reynolds et al. 1994, Woodbridge and Detrich 1994, Desimone 1997).

*Nest tree and nest site.* Nest structures in western Washington are often in Douglas-fir (*Pseudotsuga menziesii*), with western hemlock (*Tsuga heterophylla*) used to a lesser extent (Fleming 1987, Finn 2000). Nests in deciduous trees are uncommon (Fleming 1987; S. Finn and T. Bloxton, unpublished data). Deciduous trees used for nesting west of the Cascade mountain crest (e.g., red alder [*Alnus rubra*]) were generally found in the sub-canopy and isolated in coniferous forest stands comprised of less than 2% deciduous species (Finn et al. 2002b). Goshawks in eastern Washington and Oregon nest in Douglas-fir, ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*) and occasionally aspen (Finn 1994, McGrath 1997; WDFW, unpublished data). In areas of heavy mistletoe infection, goshawks will use mistletoe “brooms” as a nesting substrate (Moore and Henny 1983, Buchanan et al. 1993, Finn 1994). They may also occasionally nest in dead trees (Moore and Henny 1983; S. Desimone, unpublished data). Average nest tree size in the Pacific Northwest is >53 cm (21 in) dbh (range: 25-172 cm [10-68 in]) (Moore and Henny 1983, Fleming 1987, Bull and Hohmann 1994, McGrath et al. 2003; S. Finn, unpublished data). Goshawks build fairly large, bulky stick nests (about 0.6-0.9 m [2-3 ft] outside diameter), and nest placement is usually in the lower third of the forest canopy and relatively close to the tree trunk (Reynolds et al. 1982, McGrath 1997, Finn 2000).

Basal area at the nest site is usually higher than that of the surrounding stand. McGrath (1997) measured vegetation attributes around 82 active goshawk nests in eastern Oregon and central Washington east of the Cascade crest. At the nest site scale (1 ha [2.5 ac]), higher basal area best discriminated nest sites from random sites. Nest sites had higher average basal area/tree, and greater live stem density compared to random sites (McGrath 1997). In Montana and northern Idaho, 0.04 ha (0.1 ac) plots around nest sites (n=17) had an average of about 6 trees/plot that were >30 cm dbh (64 trees/ac >12 in) (Hayward and Escano 1989). In northeastern Oregon, Moore and Henny (1983) reported an average of 208 trees/ha >32 cm dbh (84 trees/ac >13 in) surrounding 34 nests.

Goshawks pluck the hair or feathers of their prey before consuming or bringing it to the nest for incubating/brooding females or young. Consequently, established ‘plucking posts’ (i.e., perches used to pluck captured prey) may be present within the nest area and are typically within 100 m (328 ft) of an active nest (S. Desimone, unpublished data).

*Water and topography.* It is unclear whether goshawks prefer to nest close to water, but close proximity to water may improve nesting conditions in drier forest types based on the results of several studies (see Reynolds et al. 1982, Hargis et al. 1994, Squires and Reynolds 1997). Bathing by a brooding goshawk in hot dry climates may help to maintain proper humidity in the nest during incubation, and may aid in thermoregulation (Hennessy 1978). However, Crocker-Bedford and Chaney (1988) found no association with water in Arizona where actual breeding density was high. Overall, goshawk nests in western Washington generally averaged >200 meters (654 ft) from perennial water (WDFW, unpublished data). On the Olympic Peninsula, water bodies were an average of 232 m (761 ft) from nest sites (S. Finn, unpublished data). Other studies found that goshawk nests were generally within 200-300 m (656-984 ft) of permanent water sources in Idaho (Hayward and Escano 1989), northeastern Oregon (Bull 1992), and in the eastern Cascades of Washington (McGrath 1997). However, McGrath (1997) found that eastern Oregon nest sites averaged =335 m (1099 ft) from water. Goshawk nests in east-central Washington and Oregon were generally associated with low topographic position (i.e., lower 1/3 or bottom of drainage; McGrath et al. 2003; J. Buchanan, personal communication), most likely because the larger trees at lower

elevations provided a more favorable microclimate. McGrath et al. (2003) found only a single nest near a ridge top east of the Cascades, and Bull (1992) found no goshawk nests near ridge tops in eastern Oregon.

*Nest area cluster.* Woodbridge and Detrich (1994) suggested that the aggregate of all nest stands and alternate nests within a goshawk pair's territory form a "cluster" of nest stands (i.e., "nest stand cluster"; see Figure 2). For this document, the aggregate of nest areas will be referred to as the "Nest Area Cluster" (NAC). A pair's NAC generally does not overlap with NACs of neighboring territories. NACs are variable in size and their size is believed to be less than that of the PFA (Woodbridge and Detrich 1994). It is possible the NAC coincides with PFAs, but this has not been verified. The occupancy of nesting stands (or nesting areas) by marked territorial adults was used as a basis for the NAC concept (Woodbridge and Detrich 1994).

On the Klamath National Forest in California, NACs ranged between 11 and 114 ha (26-282 ac) (Woodbridge and Detrich 1994). Occupancy rates of clusters <20 ha (49 ac) were typically less than 50%. However, occupancy at clusters that were 40 ha (99 ac) and 41-61 ha (100-151 ac) were 75-80% and about 90%, respectively, and nearly 100% of clusters >61 ha (151 ac) were occupied. Overall, long-term territory occupancy was positively correlated with the size of clusters and with larger proportions of mature forest (Woodbridge and Detrich 1994). This larger percent of area in older forest appears to provide more opportunities to maximize a pair's chance of maintaining occupancy.

Mid- and late-successional habitat is strongly associated with goshawk sites at the NAC scale. In eastern Oregon, Desimone (1997) found that substantial amounts of mid- (average dbh of 23-53 cm [9-21 in]) and late-successional (average dbh >53 cm [21 in]) forest at the NAC scale (52 ha [128 ac]) were important to the persistence of goshawks in historic territories. Occupied areas during that study had more forest area with these characteristics than historic territories without goshawks. Within the 52 ha (128 ac) surrounding historic nests, habitat around recently occupied sites was not significantly different from occupied historic sites at the time they were last known to be active. The historic sites where no goshawks were located had significantly lower amounts of combined mid-age and late-successional forest within the NAC. It was concluded that recent site conditions within the NAC that most resembled the historic conditions contributed to the persistence of goshawks in a territory over time (Desimone 1997).

## Post-fledging Family Area

The Post-fledging Family Area (PFA) contains the nest area(s) and is an area of concentrated use by adult females and developing juveniles after fledging and prior to natal dispersal (Reynolds et al. 1992, Kennedy et al. 1994). The PFA surrounds and includes nest area habitat (Kennedy et al. 1994), and provides foraging opportunities for adult females and fledgling goshawks, as well as hiding cover for fledglings (Reynolds et al. 1992). The parameters used to calculate the PFA included the average core area used by nesting females as well as the average distance juveniles dispersed from the nest tree over a specified time period (Kennedy et al. 1994). PFAs in New Mexico were high-use core areas used by breeding females that averaged 168 ha (415 ac; Kennedy et al. 1994), and may have corresponded to the defended areas of goshawk pairs (Reynolds et al. 1992). Similarly, high-use areas of adult breeding females (post-hatching) in western Washington averaged about 143 ha (353 ac) (S. Finn, unpublished data). These values are similar to the average of 168 ha (415 ac) reported by Kennedy et al. (1994) for core-use areas of breeding females.

Studies on the use of habitats by northern goshawks in the PFA indicate the importance of structurally complex forests. McGrath (1997) measured structural stages on the eastern Cascades within 83 and 170 ha (205 and 420 ac) areas around recently active nests. He found that "stand initiation phase" (clearcut/sapling stage) accounted for 7% (range 0-23%) of the 83 ha (205) plot and 10% of the 170 ha (420) plot; both values were significantly smaller than random sites. In the southwestern United States, the PFA contained 40% (by area) mature and old forest with >40% canopy closure (Reynolds et al. 1992). In eastern Oregon (with forest types similar to the southwestern U.S.) PFAs consisted of an average of 22%

(Desimone 1997) and 29% (Daw and DeStefano 2001) dense canopy, late-seral (>50% canopy closure and =20 trees/ha >53cm) forest. In western Washington, PFAs contained an average of 72% (95% CI = 59-84) mature (>10% of trees >53 cm [21 in] dbh) coniferous forest (Finn et al. 2002a). PFAs consisted of forests with a dense cover of trees and an abundant number of snags and down logs (Reynolds et al. 1992).

## Foraging Areas (breeding season) and Home Range

Foraging areas are the various habitats where goshawks secure prey. Foraging areas also define the goshawk's home range during the breeding season. Home range (HR) size estimates for goshawk pairs in western states (other than Washington) ranged between 569-3774 ha (1400-9321 ac) (Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Kennedy et al. 1994). The average HR size on managed forest landscapes in western Washington was 3710 ha (9164 ac) (range 844 to 10,730 ha [2084-26500 ac]) (Bloxtton 2002). Males generally had larger HRs than females, while HRs of non-breeders tended to be larger than that of breeders. Two years of unusually wet conditions was thought to partly explain variability in foraging distances from nests of male goshawks (Bloxtton 2002).

Goshawks forage in a variety of forest types. Limited information describing goshawk foraging habitat is available for Washington. Bloxtton (2002) found that goshawks tended to hunt in stands with larger diameter (= 50 cm [20 in]) trees, and they avoided stands in the sapling and pole stages. Kill sites had greater basal area (average = 52 m<sup>2</sup>/ha), snag density (average = 77 snags/ha = 13 cm dbh [31 snags/ac = 5 in]), large tree density (average = 62 trees/ha >50 cm dbh [25 snags/ac = 20 in]) and higher average dbh (32 cm [13 in]) than random sites. Bloxtton (2002) reported that a disproportionately high number of goshawk kill sites were in forests with a 25-36 cm (10-14 in) quadratic mean dbh (Qdbh; i.e., the dbh of a tree with average basal area in a stand) as well as in mature (35-51 cm [14-20 in] Qdbh) and old-growth (>51 cm [20 in] Qdbh) structural classes. Also, 96% of kill sites had canopy closures = 60% (average = 77%). Bloxtton (2002) noted that young (< 30 years) forests generally did not provide appropriate conditions (i.e., large trees with well developed canopies, adequate flight space beneath the canopy) for goshawk hunting.

In ponderosa pine forests of northern Arizona, breeding male goshawks preferred to forage in mature forests with higher basal areas and higher densities of trees >41 cm (16 in) dbh (Beier and Drennan 1997). In winter, foraging sites used by the same birds had higher canopy closure and more trees between 20-40 cm (8-16 in) dbh as compared to random sites (Drennan and Beier 2003). Based on these findings, one could conclude that in landscapes where the coverage of older forest has decreased, foraging areas and home ranges would become larger and territories more widely spaced (see Crocker-Bedford 1998).

Goshawks in the Cascade Range of northern California selected closed canopy mature and old-growth stands for foraging (>51 cm [21 in] average dbh and >40% canopy closure) (Austin 1993). Greater basal area, more large trees (>46 cm [18 in] dbh), and higher canopy closure characterized areas of goshawk use in eastern California as compared to random sites (Hargis et al. 1994).

Studies in the western United States (Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Desimone 1997, Patla 1997, Daw and DeStefano 2001; Finn et al. 2002a, b) indicate that mid- to late-successional forested habitats comprise a significant proportion of the total home range area. Average habitat composition of the HR (1886 ha [4660]) was 64% (95% CI 54-78) "late-seral" forest on the Olympic Peninsula (Finn et al. 2002a). Historical goshawk sites were more likely to be occupied in landscapes (i.e., home ranges) dominated by large uniform patches in late-seral stages.

## Diet

Goshawks are considered opportunistic foragers (Beebe 1974), as exhibited by the wide range of prey taken in the United States (Squires and Reynolds 1997). Douglas' squirrel (*Tamiasciurus douglasii*), grouse, and snowshoe hare (*Lepus americanus*) were the most frequently represented prey species (representing 54% of all prey in the eastern slope of the Cascade range and Okanogan county and 41% in the Olympic peninsula

and west slope of Cascade range) (Watson et al. 1998). Chipmunks (*Tamias* spp.), northern flying squirrel (*Glaucomys sabrinus*), Steller's jay (*Cyanocitta stelleri*), northern flicker (*Colaptes auratus*) and small woodpeckers (Picidae) each constituted >3% of the goshawks diet by frequency. Passerine bird species (e.g., American robin [*Turdus migratorius*]) accounted for 28% of west-side and 18% of the east-side prey by frequency (Watson et al. 1998). Goshawks in the northeastern Cascades took the highest proportions of grouse, while those in the Olympics took the fewest. Combined grouse and snowshoe hare accounted for the majority of all prey biomass consumed. Similar prey species and ratios were documented in eastern Oregon (Reynolds and Meslow 1984, Bull and Hohman 1994, Cutler et al. 1996).

In northeastern Washington and the Blue Mountains, the red squirrel (*T. hudsonicus*) replaces the Douglas' squirrel as an important food item (Hayward and Escano 1989, Patla 1997; D. Base and S. Fitkin, personal communications). In Klickitat County, a western gray squirrel (*Sciurus griseus*) was observed being taken by an immature goshawk in ponderosa pine/Garry oak (*Quercus garryana*) habitat (M. Linders, personal communication).

Bloxtton (2002) studied goshawk foraging behavior and prey use among 15 territories in an intensively managed forest landscape in western Washington. He found that grouse (ruffed and blue combined) and band-tailed pigeon (*Columbia fasciata*) were the predominant prey by frequency, followed by Steller's jay, snowshoe hare, thrushes (Turdidae), woodpeckers, Douglas' squirrel, northern flying squirrel, other rodents, and birds. Grouse and hares probably represented the majority of biomass consumed.

Given the importance of snowshoe hare in Washington goshawk diets, it is possible that goshawk territory occupancy could fluctuate in response to cyclical changes in snowshoe hare abundance (e.g., see Doyle and Smith 1994). However, the variety of prey species identified suggests that Washington's goshawks are not dependent on hare and grouse abundance because of opportunistic feeding on other prey species (Watson et al. 1998).

## Dispersal

Dispersal data for adult goshawks in the western U.S. is limited. The cycling population patterns of snowshoe hare and grouse are believed to influence periodic southward movement of goshawks from northern Canada (Squires and Reynolds 1997). Although some goshawks appear to disperse short distances during the non-breeding season, most populations are believed to be non-migratory (Johnsgard 1990, Squires and Reynolds 1997, Bloxtton 2002, Drennan and Beier 2003). These short-distance movements are likely a response to prey availability during winter (Keane and Morrison 1994, Reynolds et al. 1994, Squires and Ruggiero 1995, Drennan and Beier 2003; T. Bloxtton, personal communication). In western Washington, female goshawks had higher winter site fidelity to their breeding areas compared to their mates (Bloxtton 2002). Adult northern goshawks are not believed to make significant movements to seek new breeding sites (Detrich and Woodbridge 1994, Doyle and Smith 1994, Reynolds and Joy 1998).

Limited information is available about dispersal patterns in Washington. In one unpublished study, four immature goshawks were captured, marked, and released near Chelan, Washington, in autumn; they occupied transitional areas between coniferous forest and either subalpine parkland or lower elevation shrub-steppe savannah. Monitored until their deaths (average survival time: 13 weeks), they remained within 150 km of their banding site (J. Smith, personal communication).

## LIMITING FACTORS

Generally, the two most significant limiting factors to the long-term productivity and survival of raptors are the availability of suitable prey and nesting habitat (Newton 1979). Although the effects of timber harvesting on goshawks in the United States are not fully understood, there is evidence to suggest that harvest impacts nest site selection (Reynolds 1989, Crocker-Bedford 1990, Ward et al. 1992, Woodbridge



and Detrich 1994, Desimone 1997; Finn 2002a, b), and potentially, nesting rates (Crocker-Bedford 1990, 1995). In addition, nesting goshawks appear to be largely absent from some extensive forested landscapes in western Washington that have been intensively managed on rotations =50 years (WDFW, unpublished data). Fragmentation of suitable habitat potentially increases interaction with competing raptors (e.g., red-tailed hawks [*Buteo jamaicensis*], great horned owls [*Bubo virginianus*]) (Moore and Henny 1983, Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990, Kenward 1996). The impact of regulated falconry on wild raptor populations is thought to be minimal (Conway et al. 1995, Kenward 1997, Mosher 1997), but is largely unknown for goshawks (Squires and Reynolds 1997).

## MANAGEMENT RECOMMENDATIONS

Management recommendations for goshawks in Washington before the publication of this volume largely relied on the Northern Goshawk Scientific Committee's (GSC) recommendations developed for forests in the southwestern United States (Reynolds et al. 1992). The GSC recommendations were prescriptions that reflected a balance of different forest age classes to provide "desired forest conditions" needed to sustain goshawk populations and an adequate prey population in the U.S. Forest Service's (USFS) Southwestern Region (Reynolds et al. 1992). Many of the following recommendations for Washington are still based, at least in part, on the GSC guidelines because there is currently limited information for northern goshawks in the Pacific Northwest. However, where appropriate, some of the following prescriptions are based on recent research in western Washington.

Certain general forest types listed in the GSC guidelines may be similar to some forest types in eastern Washington (e.g., ponderosa pine and higher elevation mixed conifer) and the guidelines may be more applicable to these forest types east of the Cascade crest (S. Desimone, personal observation; R. Anthony and R. Reynolds, personal communications). Although eastern Washington vegetation data have not been fully evaluated in goshawk studies, some information exists that can be used to make limited comparisons (see Finn 1994, McGrath 1997). However, the GSC guidelines have not been assessed in Washington, particularly for moist forest types west of the Cascade crest (e.g., western hemlock/Douglas-fir and Sitka spruce zones). Also, eastern Washington lodgepole pine, moist Douglas-fir/grand fir/western larch, and true fir/Engelmann spruce (*Picea engelmannii*) forest stands have not been assessed. Overall, the GSC does not recommend applying specific management prescriptions outside of the southwestern United States. Rather, they recommend the application of general GSC model concepts elsewhere (R. Reynolds, personal communication). In addition, Anthony and Holthausen (1997) caution that the appropriateness of the PFA and foraging area estimates need to be tested for applicability to the Pacific Northwest.

### Nest Areas

Nest areas should be approximately 12 ha (30 ac) in size (Reynolds et al. 1992). At least three suitable nest areas should be protected per home range (Reynolds et al. 1992). In addition, at least three replacement areas should be present per home range, for a total of 72 ha (180 ac) (Table 2). If only one nest area is known, additional stands and replacement areas within the PFA management areas should be identified and protected. Alternate nest areas selected by managers should be structurally similar to known nest areas (Reynolds et al. 1992). Replacement nest areas are needed because goshawk nest areas are subject to disturbances such as fire and windthrow. Selection of nest areas should prioritize active or most recent nest areas over historical areas. Nest areas should be delineated using known nests and plucking posts where possible. In mixed conifer and ponderosa pine forests of eastern Washington, data from Table 2 can be evaluated with stand-specific and area data to estimate local habitat needs. All nest areas should be located within approximately 0.8 km (0.5 mi) of the goshawk pair's adjacent nest areas (Reynolds et al. 1992).

**Table 2.** Size recommendations for areas within goshawk home range as reported by the Goshawk Scientific Committee (Reynolds et al. 1992).

Attribute	Home Range Components		
	Nest Area	PFA	Foraging Area <sup>a</sup>
Total areas	6	1	1
Suitable nest areas	3	N/A	N/A
Replacement nest areas	3	N/A	N/A
Size in hectares (acres)	12 (30) each	170 (420)	2,185 (5,400)
Management season	Oct - Feb	Oct - Feb	Oct - Feb

<sup>a</sup>Foraging area figures do not include the nest areas and PFA.

Human presence should be minimized in active nest areas during the nesting season (1 March - 30 September) (Reynolds et al. 1992). Broadcasting calls for survey purposes should not be implemented until June 1 (for recommended survey protocol guidelines and information, contact WDFW's goshawk specialist in Olympia). Data on human disturbances are lacking; however, in the absence of such data, the disturbance guidelines established for other raptors should be observed: activities such as road building, logging, site preparation and herbicide and pesticide application should not occur within 0.8 km (0.5 mi) of active nests during the nesting season (e.g., Washington Forest Practices Board 2001). On known occupied territories, if the active nest is not located during the year of management activity, then a 0.8 km (0.5 mi) radius from the geographic center of previous known nest sites should be protected. Road densities should be minimized in the vicinity of nest areas and should be managed within the context of adaptive management (a systematic process for continually improving management practices by learning from the outcomes of earlier practices) (Reynolds et al. 1992).

An average canopy closure of 70-80% for both western and eastern Washington nest areas should be retained (McGrath 1997, Finn et al. 2002b). Activities conducted within suitable and replacement nest areas should be limited to those designed to enhance stand development and maintain habitat structure (Reynolds et al. 1992). Selective overstory removal, patch harvests, or clearcut harvests resulting in complete removal of trees or the reduction of large stem density and canopy volume over a landscape compromises goshawk nesting habitat (Ward et al. 1992, Crocker-Bedford 1995, Desimone 1997; Finn et al. 2002a, b). Activities in nest areas that are detrimental to desired nesting structure for goshawks should not occur at any time in areas managed for goshawks (Reynolds et al. 1992). All intact forest patches in late stages of forest development within the nest area should be retained (Daw and DeStefano 2001, Henjum et al. 1996). Fidelity of some goshawks to nest areas in winter (T. Bloxton, personal communication) underscores the importance of protecting mature and old forested habitat in nest areas to sustain resident prey populations.

No overstory or regeneration harvest should take place within the NAC at any time (Woodbridge and Detrich 1994, Desimone 1997, Daw and DeStefano 2001). For the Olympic Peninsula, controlled understory thinning to enhance development of stands for desirable nest characteristics should be carefully monitored so that dominant overstory trees are not removed and deep overstory canopy attributes are maintained (see Finn et al. 2002b); average canopy closure should remain =70%. Thinning may help younger stands develop characteristics conducive to nest habitat sooner than if left unmanaged. However, their potential for use by goshawks will be negated if the newly enhanced stands are not allowed to exist over an extended time period (e.g., 20-70 years) beyond a harvest rotation age (depending on stand age and site conditions). Thinning and stand enhancements for nest areas should be done within the context of local forest conditions and within an adaptive management framework.

## Post-fledging Family Area (PFA)

The size of the PFA should be approximately 170 ha (420 ac) in addition to the identified suitable and replacement nest areas (Reynolds et al. 1992). This area should be delineated and centered on active and alternate nest areas (i.e., the nest area cluster [Woodbridge and Detrich 1994]), and include as much mature and old forest as possible (Desimone 1997, Daw and DeStefano 2001).

In western Washington and moist forests east of the Cascade crests, canopy closure in the PFA should average  $\geq 70\%$  (Finn et al. 2002a, b), and  $\geq 60\%$  in the drier pine-dominated forests east of the Cascades (Finn 1994, McGrath 1997, Wagenknecht et al. 1998). Preference should be given to stands that are similar in structure to the nest area (Reynolds et al. 1992, Daw and DeStefano 2001). Forest management should emphasize the retention and enhancement of complex forest structure and desirable canopy closure (Finn et al. 2002a, b). PFA attribute information for eastern Washington forests is virtually unknown; therefore, forest management should avoid reducing or further fragmenting existing late-seral forest in PFAs (Beier and Drennan 1997, Daw and DeStefano 2001) until more data are collected. If possible, the PFA should not contain  $>10\%$  seedling/sapling or early forest cover (Finn et al. 2002a). Retaining snags and down logs will likely enhance goshawk prey abundance (Reynolds et al. 1992).

## Foraging Area (Home Range)

The GSC recommends that 60% of the foraging habitat be equally divided between mid-aged (20%), mature (20%), and old (20%) successional classes of forest by area based on work in the southwestern United States (Reynolds et al. 1992). These percentages might not be adequate in western Washington, because the average proportion of late-seral forest in foraging areas was at least 1.5 times that of the southwest in certain forest types (Finn et al. 2002a). In addition, goshawks made most kills in mature and older closed-canopy forest in western Washington (Bloxtun 2002). Goshawks also occupied landscapes where  $\geq 54\%$  of the foraging area (i.e., home range) was comprised of late-seral forest, and averaged no more than 11% seedling/sapling or early forest stages (Finn et al. 2002a). Based on these findings, it is recommended at least 60% of the foraging area be retained in mature and old forest. This is in addition to the mature and old forest area that should be retained in nest areas and PFAs.

Snags are important resources for sheltering birds and mammals that are goshawk prey. Large-diameter snags and logs should be retained within managed goshawk foraging areas to provide cover for important prey species. While no information exists for goshawk foraging areas in ponderosa pine forests in eastern Washington, we recommend the retention of at least 5 large ( $\geq 46$  cm dbh [18 in],  $\geq 9.1$  m [30 ft] in height) snags/ha (2 large snags/ac), and at least 7 large ( $\geq 30$  cm [12 in] diameter,  $\geq 2$  m [7 ft] in length) downed logs/ha (3 logs/ac) based on the guidelines of Reynolds et al. (1992). At least 7 large snags/ha (3/ac) with at least 12 large downed logs/ha (5/ac) should be retained in interior-fir forests (Reynolds et al. 1992). These criteria are recommended until more local information is obtained for eastern Washington.

Few studies have documented snag abundance within goshawk home range habitat in western Washington. Foraging habitat patches should be structurally similar to mimic suitable nesting habitat as well as the habitat of preferred prey. Based on Bloxtun (2002), average snag density in intensively managed habitats should average 14 snags/ha  $>30$  cm (6 snags/ac  $>12$  in); however, additional research is needed.

## Landscape Management

Planning in Pacific Northwest forests should occur at the landscape scale because site-by-site management will not maintain viable populations (Kennedy 1991, Bright-Smith and Mannan 1994, Hargis et al. 1994). Conservation and management strategies should consider multiple spatial scales (e.g., watershed, forest-wide, territory, etc.) and potential overlap between adjacent territories. Emphasis should be placed on retaining vegetative diversity and sufficient amounts of mature forested habitat for goshawk nesting and

foraging (Crocker-Bedford 1990, Reynolds et al. 1992, Bright-Smith and Mannan 1994, Hargis et al. 1994, Beier and Drennan 1997, Crocker-Bedford 1998, Finn et al. 2002a, Drennan and Beier 2003).

Because of limited information on the habitat requirements of goshawks (especially in eastern Washington), it is recommended that habitat manipulations occur using adaptive management techniques. More direct observational data of goshawk habitat use will be required to develop management plans, predict the species distribution, and aid in the assessment of habitat for goshawks on a landscape-level in eastern Washington (Dewhurst et al. 1995, Braun et al. 1996).

## Forest Management

Although largely untested, recommendations for silvicultural manipulations within goshawk home ranges have been proposed. The GSC recommended forest manipulations to benefit goshawk prey (Reynolds et al. 1992). Merrill (1989) and Lilieholm et al. (1993, 1994) recommended the use of a stand density index to manage goshawk habitat in Utah and Idaho. They provided recommendations on desirable stand conditions as well as some specific examples of stand management.

Forest stands in lower elevations of western Washington begin to develop suitable nesting habitat characteristics at about 50 years (Bosakowski et al. 1999, Finn et al. 2002b). However, current timber rotations on industrial lands are approximately 35-50 years (Finn et al. 2002b; F. Silvernail, personal communication). The net result may be the sustained loss of suitable nesting and foraging habitat in intensively managed forests in Washington. We concur with researchers (e.g., Merrill 1989; Lilieholm et al. 1993, 1994; Bloxton 2002, Finn et al. 2002a) who recommend that portions of intensively managed forested landscapes surrounding existing late-seral forest patches be allowed to mature beyond industrial rotational ages (e.g., 70-120 years on the Olympic peninsula and lowland western Washington) to benefit goshawks. Such practices would ensure that some suitable nesting and foraging habitat is available across the managed landscape. Existing occupied marbled murrelet (*Brachyramphus marmoratus*) habitat, which is composed primarily of late forest structure (Ralph et al. 1995), may potentially provide some interim goshawk nest sites (WDFW, unpublished data). However, the potential of these patches to provide adequate PFA and foraging habitat to sustain potential goshawk nest areas is limited to the size and adjacency of mature forests that are within the range of the murrelet in western Washington (i.e., generally within 80 km [50 mi] of marine waters).

To promote the development of nest habitat in western Washington, managers should thin young (30-35 years) conifer stands by removing the understory trees to a density of 345-445 trees/ha (140-180 trees/ac) (Finn et al. 2002a). This forest practice will accelerate tree growth and should eventually result in a deep overstory canopy and a low density of shrub cover if the stand is allowed to mature beyond 50-70 years.

Because goshawks have a strong fidelity to high quality nest areas, there can be a temporal lag before birds respond to habitat changes (T. Bloxton, unpublished data; S. Desimone, personal observation). Abandonment of a nest area following timber management depends on the proximity, timing, and extent of the habitat removal. Habitat assessment models and change detection (e.g., McGrath 1997, Desimone 1997) can evaluate the effects of management on site suitability. However, these processes sometimes lead to an overestimation of suitable habitat if the assumptions of the model are not explicitly addressed (McGrath 1997). A landscape-scale habitat model is currently being developed for predicting nesting habitat for goshawks in Washington (S. Finn, personal communication).

## Falconry

The impact of removing wild goshawks for falconry is thought to be negligible (Squires and Reynolds 1997). Of the various hawk species captured, Kenward (1997) estimated that 50-93% are eventually lost or released back into the wild. In Washington, falconry permit holders reported 64 northern goshawks taken from the wild between 1990 and 2002; one immature escaped and one adult died in captivity between 1998

and 2002 (WDFW, unpublished data). As the data are relatively sparse for Washington birds, the removal of northern goshawks from the wild for falconry should continue to be closely monitored.

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## KEY POINTS

### Habitat Requirements

- Home ranges for breeding goshawks can be split into three functional divisions: the nest area or areas, post-fledgling family area (PFA), and foraging area.
- Nest areas are composed of one or several forest stands that contain active or alternate nest structures that are usually occupied by goshawks between March and September.
- Nest areas are typically located in mature or old coniferous forest with a high density of large trees. Additionally, nest areas primarily are composed of stands with a closed canopy and multiple canopy layers.
- Nests are often found in Douglas-fir in western Washington and in Douglas-fir, ponderosa pine, western larch, lodgepole pine, and grand fir east of the Cascades.
- Nest areas typically have a higher basal area than that of surrounding forest east of the Cascade crest.
- Plucking posts are usually found within 100 m (328 ft) of active nests.
- Goshawks apparently prefer to nest close to water and at low topographic positions.
- All nests and alternate nests of a pair form a cluster that generally does not overlap with clusters of neighboring territories.
- The PFA is an area of concentrated use by adult females and developing juvenile goshawks.



- PFAs are typically comprised of complex forest structure and typically contain mature and old forest
- Foraging areas are where goshawks secure prey and it defines their home range during the breeding season. Goshawks forage in a variety of forest types.
- Goshawks are considered opportunistic foragers, as exhibited by the wide range of prey taken.
- Goshawks are believed to be non-migratory

## Management Recommendations

- Protect at least three nest areas and three alternate nest areas per home range. Each nest area should be at least 12 ha (30 ac) in size, and selected nest areas should be structurally similar to known nest areas.
- Minimize human disturbance in active nest areas between March 1<sup>st</sup> – September 30<sup>th</sup>.
- Retain an average canopy closure of 70-80% and maintain forest in late stages of forest development.
- Limit all overstory or regeneration harvest and increase harvest rotation length in nest area clusters.
- Delineate and center areas to managed as PFAs on active and alternate nests. PFAs should be approximately 170 ha (420 ac) and include as much old and mature forest as possible.
- Manage PFAs for  $\geq 70\%$  canopy closure in western Washington and for moist forests east of the Cascade crest. Drier forests east of the Cascade crest should have  $\geq 60\%$  canopy closure.
- Avoid removing late-seral forest in PFAs, and retain snags and downed logs.
- Retain at least 60% of foraging habitat in mid-aged (20%), mature (20%), and old (20%) forest successional classes.
- Large diameter snags and logs should be retained in goshawk foraging areas.
- Retain at least 5 large ( $\geq 46$  cm dbh [18 in],  $\geq 9.1$  m [30 ft] in height) snags/ha (2 large snags/ac), and at least 7 large ( $\geq 30$  cm [12 in] diameter,  $\geq 2$  m [7 ft] in length) downed logs/ha (3/ac) in foraging areas comprised of ponderosa pine forest in eastern Washington. At least 7 large snags/ha (3/ac) with at least 12 large downed logs/ha (5/ac) should be retained in interior-fir forests.
- Conservation of goshawk habitat should be managed on a landscape-scale and multiple spatial scales (e.g., watershed, forest-wide, territory, etc.)
- Forest management should consider increasing timber harvest rotations (e.g., 70-120 years in western Washington lowlands and Olympic peninsula) because intensively managed forest appear to negatively impact goshawks.
- Thin young (30-35 years) conifer stands to a density of 345-445 trees/ha (140-180/ac) to promote the development of nesting habitat in western Washington. If allowed to mature beyond 50-70 years, this practice should result in preferred forest conditions.
- Closely monitor the impact of the removal of northern goshawks from the wild for falconry purposes.